

# Comment on “Dark Matter with Pseudoscalar-Mediated Interactions Explains the DAMA Signal and the Galactic Center Excess”

In a recent Letter [1], the Dirac fermionic dark matter with pseudoscalar-mediated interactions has been proposed as an explanation for the Galactic Center excess, correct relic density and DAMA signal. The DAMA regions may be rejected by flavor constraints [2]. However, since the process is approximated by one-particle exchange in the simplified model approach, the inclusion of multi-particle exchange processes may change the form of WIMP-nucleus cross sections, and all bounds shall be reconsidered [3]. The authors of [1] assumed that contact interactions, with  $g_{\text{DM}g}/(|\vec{q}|^2 + m_a^2)$  replaced by  $1/\Lambda_a^2$ , remain roughly valid in calculating scattering rates at the direct detection even when the mediator mass  $m_a$  is the same order as the typical momentum transfer  $|\vec{q}|$ . To account for these observables, they find that  $m_a$  is of order 50 MeV. They expect small changes occur in their fit to DAMA due to onset of the long-range region but conclusions will not be modified.

We will show that such a replacement is not suitable. We follow [1] for notations and inputs. Adopting full form of interactions, Figs. 1(a) and 2(a) show DAMA results for universal and Higgs-like couplings in the  $m_{\text{DM}}-m_a/\sqrt{g_{\text{DM}g}}$  plane with respect to different values of  $m_a$ .  $m_a$  dependence of  $m_a/\sqrt{g_{\text{DM}g}}$  is thus shown.

In Figs. 1(b) and 2(b), we plot DAMA regions with dark matter mass  $m_{\text{DM}} \sim 40$  GeV, further including uncertainties due to variations of quark masses and  $\Delta q^{(N)}$ , and  $\gamma$ -ray excess regions in the  $m_a-m_a/\sqrt{g_{\text{DM}g}}$  plane. The DAMA (gray shaded) regions satisfy that  $m_a/\sqrt{g_{\text{DM}g}}$  (or  $g_{\text{DM}g}$ ) is constant for  $m_a \gg$  (or  $\ll$ ) 100 MeV. In Fig. 1(b), the solid and dotdashed lines, corresponding to  $\gamma$ -ray excess best fits given in [1], are for universal couplings to all quarks and only to heavy quarks ( $c, b, t$ ), respectively, where shaded regions are uncertainties ( $3\sigma$ ) from updated analyses [4]. It shows that DAMA and  $\gamma$ -ray excess regions do not overlap, even for heavy-flavor-universal couplings, for which  $m_{\text{DM}} \approx 30 \sim 50$  GeV in the  $\gamma$ -ray excess fit. (It was found in [2] that for flavor universal couplings, the DAMA signal is incompatible with the thermal relic requirement.) As for Higgs-like couplings, the two regions overlap for  $m_a \lesssim 15$  MeV, where long-range interactions, instead of contact interactions, occur at the DAMA.

In summary, we did not find the conclusion in [1] warranted.

*Acknowledgement.* This work was supported in part by the Ministry of Science and Technology of R.O.C. under Grant No: 102-2112-M-033-007-MY3.

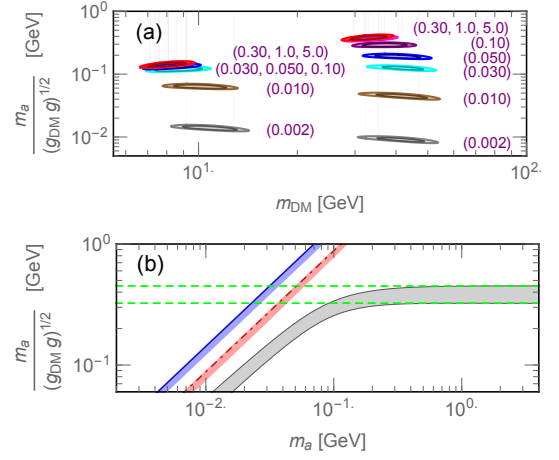


FIG. 1. (a)  $2\sigma$  (inner) and  $3\sigma$  (outer) DAMA regions in the  $(m_{\text{DM}}, m_a/\sqrt{g_{\text{DM}g}})$  plane for (heavy-)flavor-universal couplings. The corresponding number in parentheses is  $m_a$  in units of GeV. (b)  $3\sigma$  allowed regions for DAMA (gray) and for  $\gamma$ -ray excess with flavor-universal (blue) and heavy-flavor-universal (red) couplings. The range between dashed lines is for the contact limit.

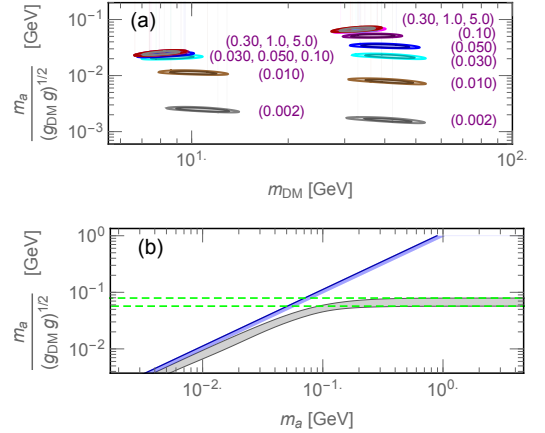


FIG. 2. Same as Fig. 1 except for Higgs-like couplings.

Kwei-Chou Yang

Department of Physics and Center for High Energy Physics,  
Chung Yuan Christian University, Taoyuan 320, Taiwan

- [1] C. Arina, E. Del Nobile and P. Panci, Phys. Rev. Lett. **114**, 011301 (2015).
- [2] M. J. Dolan *et al.*, JHEP **1503**, 171 (2015) Erratum: [JHEP **1507**, 103 (2015)]
- [3] E. Del Nobile, G. B. Gelmini, A. Georgescu and J. H. Huh, JCAP **1508**, no. 08, 046 (2015).
- [4] T. Daylan *et al.*, Phys. Dark Univ. **12**, 1 (2016).